Efficient Routing in PAN and Sensor Networks

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Presenting Papers

Efficient Routing in PAN and Sensor Networks
(P. Trakadas, Th. Zahariadis, S. Voliotis, Ch. Manasis)

A Novel Route Update Design for Wireless Sensor Networks
(Xuhui Hu, Yong Liu, Myung J. Lee, Tarek N. Saadawi)

Both appeared in
Table of Content

- Routing Problems in ad hoc networks

- Routing algorithms classification

- Overview of most important routing algorithms for ad-hoc networks

- Classify them to their relevancy and efficiency, when applied to PANs and sensor networks
  - The 2nd paper, "ERUP" is also classified into one of these categories
Routing Problems

- selecting the optimal path

- broken-down to the selection of the optimal neighbouring (or next hop)

- prevents loops

- Link failure recovery
Generally routing algorithms classification (1)

- **Proactive Routing algorithms**
  - calculates proactively consistent and up-to-date routing information
  - store that information in routing tables
  - periodically or on-demand exchanged
  - by network topology changes
    - propagate update messages throughout the network

- **Reactive Routing algorithms**
  - calculates routing information only when data is ready to be transmitted
    adopting a lazy routing approach
  - calculated path is considered valid as long as the destination is reachable or
    until the route is no longer needed
Generally routing algorithms classification (2)

- Proactive Routing Algorithms
  - Destination-Sequenced Distance-Vector (DSDV)
  - Wireless Routing Protocol (WRP)
  - Fisheye State Routing (FSR)
  - Hierarchical State Routing (HSR)

- Reactive Routing Protocols
  - Signal Stability Adaptive Routing (SSR)
  - Temporally Ordered Routing Algorithm (TORA)
  - Ad Hoc On-Demand Distance Vector Routing (AODV)
  - Efficient Route Update Protocol (ERUP)
Destination-Sequenced Distance-Vector (DSDV)

- Proactive, table-driven
- Based on Bellman-Ford Routing (distance-vector-algorithm)
- Maintains in each node
  - routing table
  - the number of hops
  - sequence number
- Sends
  - periodically the full routing table (“full dump”)
  - by changes the modified entries (“incremental update”)
- update packet contains an unique sequence number
  - transmitter assigns this SN
  - receiver selected highest SN (otherwise route with best cost metric is selected)
- Advantage / Disadvantage
  - In fast changing networks, like sensor networks, the number of incremental packets increases rapidly, then full dumps are preferred
  - In relative stable networks like Wireless PAN, incremental updates are sent to avoid extra traffic
  - Requires bidirectional links to operate
Wireless Routing Protocol (WRP)

- Proactive, table-driven
- Maintains in each node:
  - the Distance table
  - the Routing table
  - Link Cost table
  - and a Message Retransmission List
- Periodically or by link status changes:
  - exchange routing tables with their neighbours using update messages
  - in case of no changes, sends an idle “Hello” message
- By receiving an update message:
  - modifies its distance table
  - Acknowledge message is returned to the source
- Message Retransmission List contains information which of its neighbour has not acknowledged its update message
Fisheye State Routing (FSR)

- Proactive, table-driven algorithm

- enhances the Global State Routing (GSR) algorithm (a similar approach to DSDV)

- But lowers updating overheads and enables network scaling with large number of nodes

- Update information about the near (neighbouring) nodes sent more frequently than information about far nodes to reduce the packet size

- Near is defined by a radius, which is expressed as the number of Hops to the node

- Quality of the routing information decreases with each further node
Fisheye State Routing (FSR)

Precision of the information in FSR decreases to the edge
Hierarchical State Routing (HSR)

- Proactive algorithm
- Partitions the network nodes into multi-layer clusters
- In each cluster one node is cluster-parent
- Cluster-parents are organized into a higher-level of clusters and so forth
- Generating a tree-like hierarchy
- Some nodes belong to more than one cluster and are called gateways
- Each node has a network address (gateways more than one)
- If routing information is modified
  - Each node broadcasts information in their cluster
  - Cluster-parent forwards to all neighbouring cluster-parents
  - Which in return flood the information to their lower layers
Signal Stability Adaptive Routing (SSR)

- Now we start with the first reactive routing protocol in discussion
- SSR calculates a route between two nodes based on the stronger connectivity, which is calculated as the signal strength and stability of the nodes
- Maintains two tables
  - A Signal Stability Table (SST), stores the signal strength of neighbouring nodes
  - A Routing Table (RT), stores recent routes
- Routing in SSR is split in two internal protocols
  - Dynamic Routing Protocol (DRP), administers SST
  - Static Routing Protocol (SRP), administers RT
- Routing Steps
  - Received and processed by the DRP
  - DRP updates SST and forwards the packets to the SRP
  - SRP looks up the destination in the RT
    - In case of a valid entry it forwards the packets
    - Otherwise, it initiates a route-search
Signal Stability Adaptive Routing (SSR), cont’d

- If a node receives a route-request packet, it forwards the packet to the next hop only if
  - the packet is received over a channel with stronger signal strength
  - and has not been previously processed
- The destination node sends a route-reply message back to the initiator, in acceptance that the first packet arrived over the shortest path
- Based on this route-reply message, routes along the path update their routing tables
Temporally Ordered Routing Algorithm (TORA)

- Reactive protocol, highly adaptive, distributed and scalable algorithm
- Based on the concept of link reversal
- presupposes same time base on all nodes
- TORA has three basic functions
  - Route creation
  - Route maintenance
  - Route erasure
- This functionality is available with help from three control packets
  - query (QRY) : creates the paths
  - update (UPD) : used for path finding and path maintenance
  - clear : used for path erasure
- Advantages / Disadvantages
  - TORA is the most elegant and complicated approach for solving Routing Problems
  - TORA creates a couple of alternative ways to destination
  - In large, fast changing networks TORA is worse than other protocols
  - Overhead in case of reconfiguration after link failure
Ad Hoc On-demand Distance Vector Routing (AODV)

- Simple Reactive algorithm
- Improves table driven DSDV
- Instead of maintaining a list of tables, AODV minimizes the number of broadcasts by creating routes on demand
- Based only on symmetric bi-directional links
- If route required
  - broadcasts route-request packets (RREQ) to neighbours and so on
  - records the visited nodes in packet
  - destination chooses the shortest path and sends reply packet (RREP)
  - intermediate nodes enter route into their routing tables
- On link failure or source changes, the algorithm is re-initiated (RERR)
Ad Hoc On-demand Distance Vector Routing (AODV)

Example of AODV route creation
Efficient Route Update Protocol (ERUP)

- Based on AODV
- Combines routing with power saving
- Route update divided in two steps
  - Node along old route broadcast locally a Route Discovery Region packet (RDR)
  - That defines the spreading area of Route Request packets (RRQ)
  - Source node released RRQ, only nodes within RDR can rebroadcast RRQ
- So update activities are confined to a narrow strip exactly covering the old route
- Makes discovery overhead very small
- New Route mostly overlaps the old route
- Each node sends a warning signal when its power falls down
- Source initiate the route update process, when
  - 70% nodes along the path have sends warnings
  - A “powerful” node enters an active route
  - A node is out of order
Summary
Summary, cont’d

- presented the most important algorithms for PAN and sensor networks
- gave a short overview of their functionality, their problems and their solutions
- for the most protocols there are only laboratory setups,
  they are never/rarely tested in the real world

- none of these protocols covers all applications
  they all have their advantages and their disadvantages, for example
  - some protocols required bidirectional links
  - other only can used for sensor or PAN networks
  - or can only for relative stable networks
  - ...

The final selection should be based on the specific network application!
Thank you for your interest!